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| ART UNIT | PAPER NUMBER |
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| 2823 | |

DATE MAILED: 02/04/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

| Office Action Summary | Application No. 09/551,233 | Applicant(s) MATSUURA ET AL. | |
|---|---|---|---|
| | Examiner Hsien-Ming Lee | Art Unit 2823 | |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☒ Responsive to communication(s) filed on *14 November 2002* .

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

4)☒ Claim(s) *1,2,4-12,14-19 and 21-28* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1, 2, 4-12, 14-19 and 21-28* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

**Application Papers**

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

**Priority under 35 U.S.C. §§ 119 and 120**

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

**Attachment(s)**

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO-1449) Paper No(s) _____ .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: .

## DETAILED ACTION

### *Remarks*

1. Applicant's cancellation to claim 13 is acknowledged. Claims 1, 2, 4-12, 14-19 and 21-28 are pending in the application.

### *Grounds of Rejection*

*Claim Rejections - 35 USC § 103*

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. Claims 1, 2, 4-12, 14-19 and 21-28 are rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Cuchiaro et al. (US 6,165,802), Chu et al. (US 6,287,637) and Izuha et al. (US 6,060,735).

With respect to claims 1, 2, 4-12, 14, 15, 17-19 and 21-28, Cuchiaro et al. in Figs.1-5 and related text teach the claimed method of fabricating a semiconductor device having a ferroelectric capacitor 118, comprising the steps of:

* forming an active device element 110 on a substrate 102 (Fig.1);

* forming an insulation film 114 over said substrate 102 to cover said active device element 110 (Fig.1);

* forming a lower electrode layer 120 of said ferroelectric capacitor 118 over said insulation film 114, wherein said lower electrode layer includes depositing a Ti layer 116 and a Pt layer 120;

* forming an amorphous ferroelectric film of a PZT (perovskite structure) 122 on said lower electrode 120 as a capacitor insulation film of said ferroelectric capacitor 118 (Fig.1);

* crystallizing said amorphous ferroelectric film 122 by applying a rapid thermal process ( step 226 in Fig. 2 ) (col. 8, lines 21-22) in an atmosphere containing an oxidizing gas such as oxygen (col. 8, lines 20-30); and

* forming an upper electrode layer 124 on said ferroelectric film 122 (Fig.1).

Cuchiaro et al. do not literally use the "amorphous PZT" in the crystallizing step. One of the ordinary skill in the art, however, would have recognized that Cuchiaro et al. inherently teach that the treated PZT film formed in step 224, prior to the crystallizing step 226, must be an amorphous PZT. If the treated PZT film were not the amorphous PZT, then it would not be necessary to perform the rapid thermal step 226 for crystallizing.

Cuchiaro et al. do not teach crystallizing the amorphous PZT film in an ambient containing a non-oxidizing gas and an oxidizing gas; and after the crystallizing step performing an oxidizing treatment in an oxidizing ambient.

However, Chu et al. in an analogous art of forming the ferroelectric capacitor teach the steps of crystallizing and oxidizing after the crystallizing including crystallizing the amorphous PZT in an ambient of non-oxidizing gas (Ar) and an oxidizing gas (O2) followed by oxidizing the PZT film (Figs. 2a-2d and col. 7, lines 14-16, 29-32).

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to apply the steps of crystallizing and oxidizing of Chu et al. in Cuchiaro's method, since by crystallizing the PZT in the ambient of Ar and O2 it would provide a better ferroelectric performance (col. 7, lines 37-40,Chu et al.); and that by oxidizing the PZT film after the crystallizing step it would fill the oxygen vacancies and complete the crystalline structure of the PZT film (col. 5, lines 44-46, Chu et al.).

Cuchiaro et al. do not expressly teach the limitation " ferroelectric film having a columnar microstructure extending from an interface between said lower electrode and said PZT ferroelectric film in a direction substantially perpendicular to a principal surface of said lower electrode" as recited in claim 15.

However, Izuha et al. (Figs. 1-7) in an analogous art teach the claimed semiconductor device, comprising a semiconductor substrate 1; a lower electrode 4 provided over the semiconductor substrate 1; a ferroelectric film 5 on said lower electrode 4 (Fig.1), said ferroelectric film 5 (perovskite structure such as PZT; col. 4, lines 52-53) having a columnar microstructure extending from an interface between said lower electrode 4 and said ferroelectric film 5 (Fig. 4A) in a direction substantially perpendicular to a principal surface of said lower electrode 4 (col. 2, line 57 through col.3, line 45), said ferroelectric film 5 essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm (col. 6, lines 52-53); and an upper electrode 6 provided on said ferroelectric film 5; wherein said lower electrode 4 comprises a Ti layer and a Pt layer (col. 4, lines 37-45).

Therefore, one of ordinary skill in the art at the time the invention was made would have been motivated to form the semiconductor device of Cuchiaro et al., including the PZT

ferroelectric film, having a columnar microstructure extending from an interface between the lower electrode; and the PZT ferroelectric film in a direction substantially perpendicular to a principal surface of the lower electrode, as taught by Izuha et al., with a reasonable expectation of success because Cuchiaro et al., Chu et al. and Izuha et al. are utilizing similar method to form a similar ferroelectric capacitor that is a laminate film of the lower electrode, the ferroelectric dielectric and the upper electrode that are disposed in the order.

In addition, Izuha et al clearly teach that their teaching can be applied to such laminate film (col. 4, line 66 through col. 5, line 2). Accordingly, one of ordinary skill in the art would have recognized that limitations "the PZT ferroelectric film having a columnar microstructure extending from an interface between the lower electrode and the PZT ferroelectric film in a direction substantially perpendicular to a principal surface of the lower electrode", as taught by Izuha et al, are reasonably expected in the device of Cuchiaro et al. and Chu et al..

Furthermore, the combined teaching of Cuchiaro et al. and Chu et al. teach that the oxygen partial pressure is in the range of $10^{-4}$ to 100 Torr (col. 7, lines 25-28; col.8, lines 55-57; Chu et al.), which is within the claimed range. With a small amount of the oxygen (col. 7, lines 11-16, Chu et al. ) in the Ar/O2 ambient during the crystallizing step, it also inherently teaches that the oxygen (oxidizing gas) must be with a fraction of 1 to 20% in volume as recited in claim 1, line 16, claim 14, line 11 and claim 21, line 16.

Regarding claim 16, Izuha et al. teach that the crystal grains of ferroelectric dielectric, which includes PZT, is preferably in the range from 5 to 500 nm, which is in the claimed range, in order to successively grow the columnar grains from the lower electrode to the upper electrode (col. 6, lines 52-57).

Therefore, it would have been obvious to one of the ordinary skill in the art to control the crystal grains of the ferroelectric dielectric in the claimed range, as taught by Izuha et al., during the formation of the PZT film in Cuchiaro's method since by this manner it would ensure the direction of grain growth to be substantially perpendicular to a principal surface of the lower electrode towards to the upper electrode.

***Response to Arguments***

4. Applicant's arguments and amendment filed 11/14/02 have been fully considered but they are not persuasive because of the reasons as follow.

Applicants argument is on the ground that "Chu et al. is not specific about oxygen partial pressure used in the experiments of FIGS.2a-2d thereof " ; that Chu et al. do not mention " the oxygen partial pressure is controlled in their experiments of FIGS. 2a-3d"; and that the claimed range of oxygen concentration is not described or even suggested in Chu et al. (third and fourth paragraphs, page 4).

Applicants further argue that even though Chu et al. describe the oxygen partial pressure for crystallizing the PZT film in rapid thermal anneal chamber is in the range of $10^{-4}$ to 100 Torr, this does not mean that the preferable range of oxygen concentration for annealing is in the claimed range. ( second paragraph).

Contrary to arguments, Chu et al. expressly teach the claimed oxygen partial pressure for crystallizing the amorphous PZT film in the annealing chamber. Particularly, Chu et al. in col.7, lines 22-28, state that " The assignee of the invention ... has used Argon rich ambient gas to crystallize PZT films ... in an Argon/oxygen ambient atmosphere have been built and evaluated"

and " the oxygen partial pressure in Ramtron's RTA (rapid Thermal Anneal) chamber is $10^{-4}$ to 100 Torr. Chu et al. further state that " the method of claim 7 in which the oxygen partial pressure in the annealing chamber during said high temperature crystallization is $10^{-4}$ to 100 Torr." (col.8, lines 55-57), which **covers** the claimed range "between 1 Torr and 40 Torr." By choosing the aforementioned oxygen partial pressure range, Chu et al. suggest that the perovskite structure can form with a large amount of $O_2$ vacancies embedded in the structure, which would provide effective paths for lead cations to migrate in the PZT film, giving rise to a more uniform lead distribution and more homogeneous formation of a perovskite phase (col.7, lines 2-10).

Therefore, Chu et al. **do** expressly teach the claimed limitation " crystallizing said ferroelectric film by applying a thermal annealing process in an oxygen atmosphere under a reduced total pressure in the range between 1 Torr and 40 Torr."

In addition, with a small amount of the oxygen (col. 7, lines 11-16,Chu et al.) in the Ar/O2 ambient during the crystallizing step, Chu et al. also inherently teach that the oxygen (i.e. the oxidizing gas) is with a fraction of 1 to 20% in volume. Regarding the claimed range " an oxidizing gas with a fraction of 1 to 20% in volume" as recited in claim 14, applicants are required to show the criticality, generally by showing that the claimed range achieves **unexpected** results relative to the prior art range. See M.P.E.P. 2144.05 III.

Applicants further argue that Izuha does not show that the column grains have a generally uniform grain diameter. (second paragraph from the bottom of page 4).

Contrarily, Izuha does suggest that the PZT ferroelectric film 5 consisting column crystal grains having the size from 5 to 500 nm are grown so **uniform** that these grains are nearly perpendicular to the principal surface of the lower electrode 4 as shown in Fig. 6 (col.10, lines 7-

12); and that the columnar grain size A of the PZT ferroelectric film 5 are the **same** as that of lower electrode 4 and upper electrode 6 (col.11, lines 32-41). With these uniform grains in the PZT ferroelectric film 5, it is even difficult to distinguish the boundary between each layer (col.11, lines 47-49).

For the above reasons, the rejection as set forth in the previous Office Action is deemed proper.

***Conclusion***

5. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Hsien-Ming Lee whose telephone number is 703-305-7341. The examiner can normally be reached on M-F (9:00 ~ 5:00).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached on 703-306-2794. The fax phone numbers for the

organization where this application or proceeding is assigned are 703-305-0142 for regular communications and 703-305-0142 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Hsien Ming Lee
January 31, 2003

Olik Chaudhuri
Supervisory Patent Examiner
Technology Center 2800